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# Proceedings of the Second West Midlands Health Informatics Network Conference (WIN 2016)

**Guest Editors: Sarah N. Lim Choi Keung and Theodoros N. Arvanitis**

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The West Midlands Health Informatics Network (WIN) represents over 750 members in the West Midlands region of England, United Kingdom, and further afield. Regular meetings and events are held throughout the year and these are announced on our website <http://www.wmhin.org>. The Second Annual Conference was held on the 26<sup>th</sup> January 2016.

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## Peer Review

A selection of oral presentations and posters were reviewed by a WIN committee and the DIGITAL HEALTH Editors-in-Chief made their final selection for publication from these. The selection of eight abstracts took into consideration the scientific contribution of the works presented.

## Standards for Telehealth Services

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Telehealth services are developing in different ways (embracing mHealth, medication compliance, telecare, vital signs monitoring and activity monitoring). The need for appropriate service standards, norms or codes has never been greater. This paper explores a selection of standards from different European countries, North America and Australasia. Emerging trends in their development are identified that point to their increasing flexibility; and their evolution in a way that may help to foster a move away from

‘top-down’ prescriptive and, possibly, towards more integrated approaches.

## Introduction

Telehealth services operate in a number of domains including mHealth, medication compliance, telecare, vital signs monitoring and activity monitoring. They can be approached from two different directions – from clinical health or social care. Each of these approaches has histories, traditions and professional dogmas that have been re-enforced by standards, norms or codes (henceforth standards). The standards have provided some of the certainties that frame our personal or professional lives. They have offered ‘comfort zones’ for those who plan, commission or provide services. But telehealth cuts across such certainties. The technologies that are part of such services and the manner of their use increasingly disrespect traditional boundaries. This is especially the case when they are acquired by people who have health and support needs but are (as is increasingly the case) able and keen to exercise greater choice about the services and sources of information that they access. It follows that the role of standards as we know them (and which helped to determine some of the established health and social care approaches) can be questioned.

## Methods

This paper reports on initial findings of research into telehealth related standards in different European countries, North America and Australasia. It begins to give shape to what Krupinski and Bernard referred to as ‘differences in approaches and norms for conducting telehealth’<sup>1</sup> and responds to what the European Commission lamented as the ‘lack of regulation at the EU level’.<sup>2</sup>

A key objective in the research is to explore the content of a selection of standards and the way in which they

- a. help or hinder telehealth service development (by reference to their content and the degree to which they prescribe certain ways of operation); and



- b. support particular (changes in) attitudes and the process of integration between health and social care.

From the social care perspective the standards explored extend from the early offerings of the British Standards Institution in the 1990s<sup>3</sup> to the AENOR ‘Teleassistance’ Code (for Spain)<sup>4</sup> and the Telecare Services Association’s ‘Integrated Code’ (for the United Kingdom)<sup>5</sup> – both released in 2013. Other standards that can be seen as emanating from a social care direction (around social alarms and telecare) are noted from Australia<sup>6</sup>, France<sup>7</sup>, the Netherlands<sup>8</sup> and New Zealand.<sup>9</sup>

From the clinical health direction the focus is on ‘home telehealth’ where standards have been promulgated from 2002 by the American Telemedicine Association (ATA) through to their 2014 ‘Core Operational Guidelines’.<sup>10</sup> In addition it is necessary to note the significance of the ISO 2014 standard for ‘Telehealth Services’ as guiding service operation from a largely clinical perspective.<sup>11</sup>

Taking a more intermediate approach (i.e. seeking to accommodate social care and clinical perspectives) are the Telehealth Quality Group’s ‘International Code of Practice for Telehealth Services’<sup>12</sup> and the Accreditation Canada ‘Telehealth Services’ code.<sup>13</sup> Both of these offer ‘framework’ approaches that point to key outcomes that can permit flexibility in service operation and development.

## Results

From the social care side of things it is clear that ‘standards thinking’ around telehealth has focused on social alarms and telecare. That thinking has been, in large, concerned with service ‘operation’ and the setting of formulae that determine a particular way of doing things. This means that flexibility and pointers to any scope to innovate and develop has, generally, been lacking. A similar ‘operational’ and formulaic perspective is evident from the clinical health side of things in ‘home telehealth’. But with regard to the latter it is significant that the ATA has maintained awareness of the broader social care agenda – and, with this, offers a somewhat less prescriptive standards approach.

The extent to which standards have tended to be prescriptive is evident from, first, the degree to which operational procedures as opposed to service outcomes are specified; and, second, whether (and the number of) readily quantifiable ‘performance indicators’ are included. It can be noted, therefore, that the AENOR (Spain) 2007 and TSA (UK) 2013 codes respectively specify 8 and 14 quantifiable performance indicators that can be required to be satisfied by services, whereas

the Accreditation Canada 2014 and the Telehealth Quality Group 2016 codes, whilst giving attention to service outcomes, do not include these. A pointer to more integrated service approaches is also signalled in the Telehealth Quality Group and Accreditation Canada codes by their holding, respectively, to the terms ‘service user’ and ‘client’ (both eschewing the term ‘patient’) whilst seeking to ensure that services address aspects of people’s wider well-being as well as their clinical health.

## Discussion

In examining the range of standards noted above, three trends are indicated.

First is the trend towards standards that are more flexible. There is, therefore, less emphasis on ‘how to do it’ and *ipso facto* less prescriptive operational approaches. The exceptions are for particular telehealth-related ‘tasks’ such as personal data management, or in relation to technical requirements that demand, for example, the continuous availability of communications networks. This means that, at least in part, standards may, in the range and content of their individual clauses, be increasingly allowing for different telehealth service approaches. This can be argued as important in order to accommodate the way in which new technologies are becoming available; and may help foster innovations in service development. Within such ‘more flexible’ standards there is less emphasis on specific performance ‘indicators’, albeit that services may be called upon to report openly on their performance.

Second is the trend away from top-down approaches that have reflected views of telehealth that may have been driven more by the interests of professionals (within service provider organisations, manufacturers and suppliers) than service users. This trend relates, in part, to the advent of new and cheaper technologies (including those relating to mHealth) that mean service users are accessing health and related support services in new ways. It also relates, in part, to a consumer-driven agenda where people are more and more assertive with regard to their needs and service choices. Terminological markers such as ‘service users’ as opposed to ‘patients’ reflect this trend. There are, in addition, more clauses within standards that are concerned with the rights of service users and the ways that they are engaged.

A third trend can be identified, though with less certainty. This is the trend towards service integration – something that is particularly strongly championed by the European Union (as, for instance, exemplified in the EIP on AHA – the European Innovation Programme in Active and Healthy Ageing).<sup>14</sup>

The EIP on AHA sees the need for a break-down in the barriers that are extant in some European countries – not just between health and social care but also between primary and secondary healthcare. Those barriers are seen as thwarting the provision of more user-driven service approaches. Telehealth and related technologies, supported by appropriate standards, are seen as potentially contributing to the break-down.

## Conclusion

The nature of standards for services in telehealth is evolving in a way that, at least in the medium term, holds the promise of more flexible and less prescriptive service approaches. The relevant standards that have been put in place are few in number but point to towards the trends of increasing flexibility and a stronger service user orientation. A third trend towards more ‘integrated’ service approaches, may become evident and is, arguably, a likely consequence of the way that people are increasingly using different technologies and are better able to choose the services that they might wish to access.

All of the standards can be seen as relevant in some specific service areas but many can be regarded as restrictive in a context where telehealth services are seen as a possible means by which barriers to innovative service development can be overcome. Trends are beginning to be evident, however, that suggest that standards, as they evolve, will increasingly support more flexible telehealth service approaches and that that these may help them to fulfil a more meaningful ongoing part in health and social care.

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## Is There a Need for Renal Computerised Clinical Decision Support in a University Hospital Setting?

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A baseline audit to explore whether Computerised Clinical Decision Support (CCDS) is needed when prescribing for patients with renal impairment in a University Hospital setting. We aimed to identify prescriptions that did not adhere to dosing guidelines from the Renal Drug Handbook. We captured regular prescription data from the hospital EPMA audit database, which was then refined and analysed. We concluded that there is scope for the implementation of CCDS which may have a positive impact on prescribing adherence and patient safety.

## Introduction

Electronic Prescribing and Medication Administration (EPMA) systems are being implemented across a number of hospital sites in the UK. This technology may have a number of digitally mature capabilities, such as Computerised Clinical Decision Support (CCDS). CCDS systems match individual patient data to a computerised knowledge base, and use software algorithms to generate patient-specific recommendations.

In this study, we describe a baseline audit undertaken to explore whether there is a need for CCDS to guide practitioners when prescribing for patients with renal impairment. We aimed to identify prescriptions that did not adhere to the dosing guidelines outlined in the Renal Drug Handbook.

## Methods

A number of 'high-risk' drugs or drug classes have been identified that may need to be avoided or adjusted in patients with renal impairment.<sup>1</sup> For each drug, we captured prescription data from the University Hospital Birmingham NHS Foundation Trust EPMA system (PICS).

The following data were extracted for all inpatient episodes over a 12-month period (2014–15):

- **Prescription details:** drug name, form, dose, frequency, route, time prescription generated, and grade of the prescriber.
- **Patient demographics:** estimated Glomerular Filtration Rate (eGFR) prior to the first and last administration of the medicine and the speciality the patient was under the care of when the prescription was generated.

The first and last dose for each prescription were coded to identify whether the treatment was consistent with the dosing guidelines in the Renal Drug Handbook.<sup>2</sup> Cases of non-adherence were coded as a 'dose discrepancy', and may have been supra-therapeutic, depending on the patient's eGFR. We analysed the data to explore a number of temporal (time of day, day of week, month of year), patient (eGFR, speciality) and prescriber factors (grade) and compared the rate of dose discrepancies across factors using Chi<sup>2</sup>-tests. This study was approved by the University Hospitals Birmingham Foundation Trust and is exempt from NHS Research Ethics Committee approval.

## Results

Out of the 72 high-risk drugs or drug classes that need to be avoided or adjusted in renal impairment<sup>1</sup>, data were available for 25 from PICS (accounting for

non-formulary medicines, or medicines that were not prescribed on a regular basis).

A total of 74,501 prescriptions were captured, 11,287 of which were excluded as they were prescribed as single (one-off) doses or on a when required basis, hence the daily doses were not known. Of the 63,214 prescriptions remaining, 92% (n = 58,295) of these were prescribed for patients with an eGFR at both their first and last dose that did not warrant a change in the dosing regimen. A further 850 prescriptions were removed from the analysis since the patient only received one dose. A total of 4069 prescriptions were analysed for a dose discrepancy, of which 656 (16%) had a first dose discrepancy and 648 (16%) had a last dose discrepancy.

We found the rate of dose discrepancies changed significantly across the time of day, patient eGFR and speciality (see Table 1).

Out of the 25 drugs analysed, morphine sulfate was the most frequently prescribed (30%, n = 1233/4069), with 18% of prescriptions having a first dose discrepancy, increasing to 21% for the last dose (see Table 2). There were cases where drugs continued to be prescribed despite being contraindicated in renal impairment, in particular the Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) ibuprofen, naproxen and piroxicam (N = 50, 1%).

## Discussion

In this study we found that dose discrepancies occur in patients with renal impairment, albeit at a low rate compared to the total number of prescriptions generated on a daily basis. The decrease in the rate of dose discrepancies throughout the day may be attributed to a difference in workload in the evening. Dose discrepancies were also found to vary significantly with eGFR, becoming less common in patients with more severe renal impairment. This may be due to prescribers being more aware of the need for dose adjustment at lower eGFRs. The rate of discrepancies did not vary significantly across the grades of the prescriber, which may indicate the decision is one discussed as a team and that training or interventions to improve prescribing in this patient group should be targeted at all prescribers. Patients under the surgical specialities (ear, nose and throat, neurology and plastics) were found to have the highest rate of dose discrepancies, but had a lower opportunity for error owing to the number of prescriptions generated. This may identify a need to focus training or any initial implementation of CCDS at specialities that may prescribe fewer drugs that are cautioned or contraindicated in renal impairment.



**Table 1.** Comparison of dose discrepancy rates across temporal, patient and prescriber factors.

	Total Prescriptions	Dose Discrepancies on First Dose
<b>Time of Day (<math>p &lt; 0.001</math>)</b>		
0:00 — 7:59	863	183 (21%)
8:00 — 12:59	1249	275 (22%)
13:00 — 17:59	847	99 (12%)
18:00 — 23:59	1110	99 (9%)
<b>EGFR (<math>p &lt; 0.001</math>)</b>		
<15	1153	150 (13%)
15–29	1189	177 (15%)
30–44	1126	200 (18%)
45–59	595	129 (22%)
60–90	6	0 (0%)
<b>Speciality (<math>p &lt; 0.001</math>)</b>		
Ambulatory Care	65	17 (26%)
Burns Surgery	18	1 (6%)
Cardiology	160	21 (13%)
Cardiothoracic Surgery	161	36 (22%)
Clinical Haematology	51	5 (10%)
Critical Care	126	22 (17%)
Ear, Nose & Throat	15	7 (47%)
General Medicine	1512	267 (18%)
General Surgery & GI Medicine	208	45 (22%)
Liver	176	30 (17%)
Maxillofacial Surgery	8	2 (25%)
Neurosciences	32	10 (31%)
Oncology	97	18 (19%)
Plastic Surgery	49	15 (31%)
Renal	916	78 (9%)
Trauma & Orthopaedic	192	27 (14%)
Urology	169	33 (20%)

(continued)

**Table 1.** Continued.

	Total Prescriptions	Dose Discrepancies on First Dose
Vascular Surgery	114	22 (19%)
<b>Overall</b>	<b>4069</b>	<b>656 (16%)</b>

Day of the week ( $p = 0.633$ ), month of the year ( $p = 0.267$ ) and prescriber grade ( $p = 0.434$ ) were also considered, but not found to be significantly associated with dose discrepancy rates

**Table 2.** Comparison of dose discrepancy rates by drug.

	Total Prescriptions	Dose Discrepancies on:	
		First Dose	Last Dose
Drug (p < 0.001)			
Amikacin	2	2 (100%)	2 (100%)
Amiloride Hydrochloride	9	0 (0%)	0 (0%)
Amoxicillin	19	0 (0%)	0 (0%)
Bendroflumethiazide	2	2 (100%)	2 (100%)
Cefalexin	23	0 (0%)	0 (0%)
Ceftazidime	5	4 (80%)	4 (80%)
Cefuroxime	5	0 (0%)	0 (0%)
Co-amoxiclav	135	96 (71%)	47 (35%)
Digoxin	420	6 (1%)	3 (1%)
Enoxaparin	1059	10 (1%)	18 (2%)
Flucloxacillin	62	0 (0%)	1 (2%)
Fungizone	4	4 (100%)	4 (100%)
Gentamicin	8	0 (0%)	0 (0%)
Ibuprofen	40	40 (100%)	40 (100%)
Indapamide	1	1 (100%)	1 (100%)
Metformin Hydrochloride	317	236 (74%)	227 (72%)
Methadone	3	2 (67%)	2 (67%)
Morphine	1233	220 (18%)	265 (21%)
Naproxen	9	9 (100%)	9 (100%)
Piperacillin/Tazobactam	297	18 (6%)	16 (5%)

(continued)

Table 2. Continued.

	Total Prescriptions	Dose Discrepancies on:	
		First Dose	Last Dose
Piroxicam	1	1 (100%)	1 (100%)
Rosuvastatin	58	2 (3%)	2 (3%)
Simvastatin	138	1 (1%)	1 (1%)
Spironolactone	212	1 (0%)	2 (1%)
Vancomycin	7	1 (14%)	1 (14%)

## Conclusion

Improving adherence to prescribing guidelines in renal impairment would have a positive impact on patient safety, and this may serve as evidence for the implementation of CCDS. We are currently in the process of deciding how to implement this intervention. To establish whether this CCDS intervention could be used to increase adherence and improve patient safety, we will carry out a post implementation audit.

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**Ethical approval:** This study is exempt from NHS Research Ethics Committee approval. It has been approved by the University Hospital Birmingham NHS Foundation Trust Clinical Audit Team (Audit Code CARMS-12687).

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## The Framework for Compassionate Interpersonal Relations in Health and Social Care

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Despite compassion being a key area of concern in health-care, there is a lack of shared understanding of this term. In this study, 45 academic staff, health care students, clinicians and services users took part in focus groups in which they defined and discussed compassion. Following thematic analysis, the Framework for Compassionate Interpersonal Relations was developed with five stages, each of which requires practitioners' concerted efforts, energy and the application of a range of skills.

## Introduction

Compassion has become particularly important in the context of health and social care provision. The highly publicised failures to provide care to ill and vulnerable people such as at Winterbourne View<sup>1</sup> and Mid Staffordshire NHS Trust<sup>2</sup> has led some to conclude that there is a 'crisis of compassion' within the NHS. Indeed, the issue of compassion has been high on the Government agenda for some time.<sup>3</sup> For example, the Prime Minister's Commission on the Future of Nursing and Midwifery<sup>4</sup> urged the professions to make a pledge to deliver high quality compassionate care. The Chief Nursing Officer's<sup>5</sup> 'Compassion in Practice' strategy detailed a set of six values and behaviours essential to compassion in practice and to improving the culture of care.

Compassion, however, is a complex phenomenon and although it is an oft used word, it is a subjective criterion that is not well articulated. This is largely because the word compassion is used linguistically to refer to a range of acts, rather than a single one.<sup>6</sup> For example, compassion may include empathy, respect, building relationships with others, and 'being with' another person at a time of suffering.<sup>7</sup> Compassion may also come to light in different contexts and mean different things to different people at different times.<sup>8</sup> Indeed, each person may possess a different understanding of what the word compassion means, although it has been argued that it is a construct that is distinguishable from other concepts such as 'sympathy, empathy and pity'.<sup>9</sup> The aim of this project, therefore,

was to explore the perspectives of stakeholder groups to identify a common understanding of compassion, which led to the development of the Framework for Interpersonal Relations.

## Methods

A 'pragmatic' qualitative approach was adopted, which is a practical method that seeks understanding of people's descriptions and interpretations without being wedded to either an ethnographic, phenomenological or grounded theory approach.<sup>10</sup> Forty-five academic staff, health care students, clinicians and service users participated in nine focus groups. A discussion schedule was developed specifically for the project, following a review of the literature. The schedule was reviewed by a project advisory board of the research team, University health- and social care staff and lay members of a Research Support Volunteer Panel. Two questions formed the main core of the discussion: how would participants define compassion; and, what behaviours indicate that a health care professional is compassionate.

## Results

Four overarching themes were drawn from the data. The first theme centred on the participants' definitions of compassion, while the second identified compassionate behaviours. The third theme related to the barriers and threats to compassionate practice and the fourth, focused on ways to support compassion in practice. Participants believed that the healthcare staff should be 'consistently compassionate', and were emphatic that compassion should not be substituted with a 'care without engagement' approach. Participants held clear expectations regarding practitioners' communication skills and used these as a proxy for compassionate practice.

The 'Framework for Compassionate Inter-personal Relations' was developed from the data with the following five key stages.

1. Stage 1: *Connecting*, where the compassionate practitioner engages and connects with the patient by giving his/her full attention, using active listening skills, positive nonverbal communication skills and appropriate verbal skills.
2. Stage 2: *Recognising feelings*. For genuine compassion to be experienced by the patient, these feelings need to include empathy and concern for the patient, his/her situation or difficulties.
3. Stage 3: *Becoming motivated*, where feelings of empathy and concern for the patient are harnessed as a desire to help or a force for action to support the patient.
4. Stage 4: *Taking action to help*, where the professional implements the plan of action, draws on personal agency and experiences and the support of others to help the patient.
5. Stage 5: *Sustaining relationships*, where the professional continues to use the skills from stage 1 to sustain the positive relationship with the patient and supplements these by providing the patient and relevant others with information, ongoing explanation and involving the patient.

Each stage of the cycle requires the practitioners' concerted effort, energy and the application of a range of skills.

## Discussion

The findings support previous research that has identified the link between empathy, compassion and the importance of establishing meaningful connections with others. Style of communication, whether an individual invested time in developing a positive interpersonal relationship, and level of personal engagement was used by participants to determine whether a practitioner was compassionate or not. Care given without personal engagement was viewed as non-compassionate. The findings of the study should be interpreted with care, since the number of participants from each stakeholder group was small and representative of a fairly small geographical area in the UK; hence the findings might not be representative of these stakeholder groups nationally. Nevertheless, the views across the stakeholder groups were similar, indicating some level of shared agreement. Compassionate care was seen as an important goal, even though participants in the study recognised the pressures of health care work and accepted that the expectation of 'consistent compassion' was not necessarily realistic. Care is needed to avoid a mechanistic, simplified view of compassion, rather than compassionate relationships centred on patients' needs; hence this framework may be of value.

## Conclusion

Participants held clear expectations regarding practitioners' communication skills and used these as a proxy for compassionate practice. The 'Framework for Compassionate Inter-personal Relations' may be used to promote reflection on the implementation of compassionate practice and highlight areas of focus when conducting values-based recruitment activities.



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The details of this study were first published in Kneafsey, R., Brown, S. J., Sein, K., Chamley, C., Parsons, J. What do we mean when we talk about 'compassion' in health care? A qualitative exploration of academic, clinical and lay perspectives. *Journal of Clinical Nursing*. 2015; 25:70–79.

## The Role of Informatics in Prehospital Emergency Resuscitation and Defibrillation

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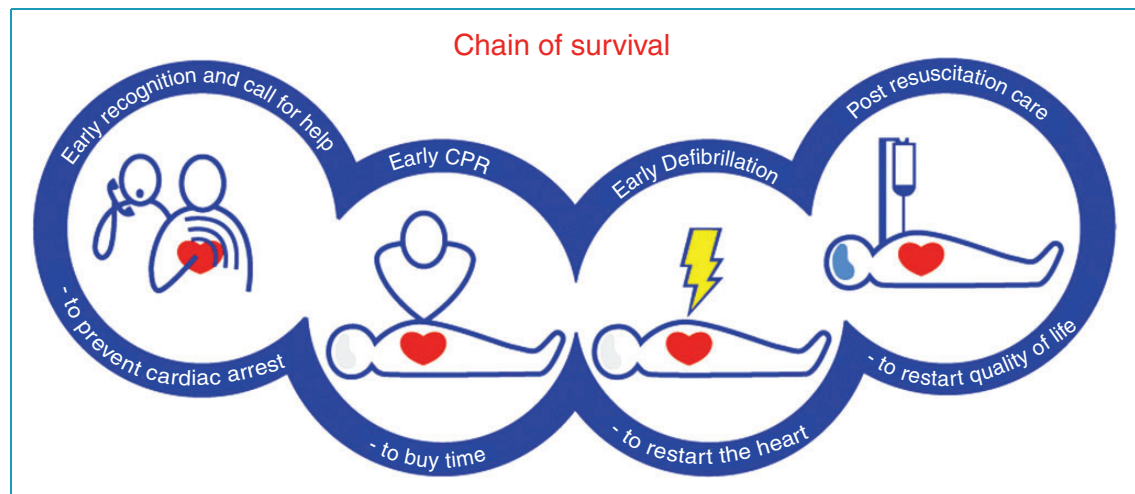
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Out-of-hospital cardiac arrests account for a large number of deaths as the time window for successful resuscitation is very short. Timely call for help, resuscitation and defibrillation by laypersons are crucial for the survival and outcome of cardiac arrest victims. Good quality data and informatics play an important role in the effectiveness of the chain of survival. Information about defibrillator location is vital for emergency services to direct bystanders; informatics also helps to strategically place defibrillators for optimal use. Technologies, such as location-based systems are being used to keep track of defibrillators and also alert volunteer responders to emergencies. Informatics also plays a role in post resuscitation care and research by facilitating the linkage and interoperability of health data between different systems, such as ambulance service, hospital, and other health data such as cardiac arrest registries.

## Introduction

In 2013 the emergency medical services (EMS) attempted to resuscitate approximately 28,000 cases of out-of-hospital cardiac arrest (OHCA), in England alone<sup>1</sup>. If more bystanders had the confidence and skills to call 999 quickly, deliver effective cardiopulmonary resuscitation (CPR) until the EMS arrive, and when appropriate use a public access defibrillator (PAD), the number of cases where the EMS could attempt resuscitation, and so save lives, would increase. The overall average survival to hospital discharge from the 28,000 EMS-treated OHCA in England is 8.6%, which is significantly lower than in other developed countries, such as North Holland 21%, Seattle, USA 20% and Norway 25%. PAD use is still low in OHCA, for instance, in the south of the UK, 1.75% was reported in 2012<sup>2</sup> and internationally, PAD use has been reported in between 0.5% and 4.9% of OHCA. In the event of a cardiac arrest, every minute without CPR and defibrillation reduces the chances of survival by about 10%, hence early bystander CPR and



**Figure 1.** Chain of survival. Reproduced from *Resuscitation*, 71(3), J Nolan, J Soar and K Eikeland, The chain of survival, 270–271, 2006, with permission from Elsevier.

defibrillation being vital to improve patient outcome for OHCA in for first few minutes before the arrival of EMS.

The chain of survival (Figure 1<sup>3</sup>) ensures that an OHCA victim has the best chances of survival and outcome. Having the right information at each of the chain link is key to the effectiveness of the entire chain. In this paper, we present how digital technologies are used and how data is acquired, maintained, retrieved, and applied to support the chain of survival.

## Methods

A feasibility study into a national PAD database was conducted to gather and analyse findings to answer four main questions: (1) what are the characteristics of an effective PAD programme? (2) What are the facilitators and barriers to PAD use? (3) How can a PAD database contribute to an effective PAD programme? (4) What systems have been used to map PADs and what are their effectiveness and cost? The study included a rapid review of the published and grey literature; consultations with key stakeholders; and international experience from an International Advisory Group.

## Results

The first link in the chain of survival is preparedness, the early recognition of cardiac arrest and calling for help. The second link is for early CPR until emergency services arrive. Members of the public can prepare for such events through training and awareness sessions, many of which are conducted by ambulance services

in the UK. A number of mobile apps are available for resuscitation training, but most focus on CPR with little coverage of use of a defibrillator<sup>4</sup>. Preparedness also includes having PADs in locations where OHCA happen. PAD programmes have been set up in many countries to place AEDs so they can be used in cases of OHCA. Different approaches have been used to strategically place AEDs for optimal effectiveness, such as using OHCA incidence data, or use the characteristics of locations, for instance busy areas as airports and train stations, or type of activity, such as gyms or leisure centres. Mathematical models have also been used to strategically place AEDs for optimal geographical coverage while still being within reach of bystanders fetching the AED.

The third chain link is early defibrillation. A number of reasons account for the low use of automated external defibrillators (AEDs). One of them is the lack of information about their location – emergency services can only direct bystanders to a PAD if they know where it is. All 14 ambulance services in the UK have their own register of AEDs and they gather that information in a number of ways, including placing or maintaining the AEDs themselves; encouraging AED owners to report their devices via the manufacturer, online registration or registration campaigns. There are other groups that also have AED registers who may or may not work with the local ambulance service. The cluttered landscape for AED registration can cause confusion for AED owners and the public. The granularity and quality of information in the registers also vary. Some registers have only information about the location, availability (24/7 or restricted times) and accessibility of AEDs (unlocked or code needed). While others

also have information about consumables, such as battery and pads that have expiry dates. New methods of automatically locating and maintaining AEDs are starting to be available, for instance, the use of unique device identifiers, GPS-location, machine-to-machine communication, as well as self-testing and notification capabilities.

There are three main types of apps and systems for mapping AEDs. The first type are for awareness and usually have a map showing the locations of AEDs, e.g. South Central Ambulance Service app<sup>5</sup>. The second type alerts volunteer responders of OHCA events close to where they are located so they can respond. The third type involves the alert and dispatch of volunteer responders by emergency services directly from their computer assisted dispatch (CAD) systems – many systems in the second category have these features, e.g. PulsePoint<sup>6</sup>, GoodSAM<sup>7</sup>, FirstAED<sup>8</sup>, Heartsafe Living<sup>9</sup>. Those two categories of systems keep a database of volunteer responders with their real-time locations and enable them to respond or decline requests to assist.

The fourth link in the chain of survival is post-resuscitation care, usually when the OHCA victim is taken by the ambulance service to hospital for follow-up care. To support this process, clinicians at the hospital need to know as much information as possible about the patient and how an AED was used. In the UK, patient records at the ambulance service are largely separate from the hospital records and handovers are not done using electronic means. Important information also lies within the AED itself and this information is not systematically downloaded. Challenges include the lack of standardization which means that information can be downloaded from devices using USB ports, memory cards, etc. and AED manufacturers have their own software to support the download process. The AED data is useful for clinical care and research, but some AEDs have limited memory and data may be lost if data is not downloaded regularly.

Linking back to preparedness is to prepare and return the used AED to its original location, ready to be used. Informatics plays a role in this step as owners need to be notified that their AEDs have been used and need to have the consumables replaced. Additionally, ambulance services set used AEDs as inactive on their CAD system, until they have been serviced. Increasingly automated solutions to support these processes will ensure the effectiveness of the chain of survival.

## Discussion and Conclusion

Public access defibrillators play a vital role in the positive outcomes of OHCA victims, especially when they are used by laypersons before the arrival of emergency

services. In this paper, we presented where informatics is used at different points along the chain of survival. The collection, maintenance and retrieval of AED location information is crucial for emergency services to be able to accurately direct lay responders to accessible, available and working AEDs. Advances in automatic alerts to first responders via mobile apps are increasingly involving the community in actively participating in emergency situations when ambulance services would often be too late for an OHCA victim. Increasing the automation for AED maintenance alerts to facilitate the process for AED owners should be considered, especially as an increasing number of PADs are being purchased. Finally, improving the linkage of electronic records between ambulance services and hospitals, as well as other relevant health and care data can help to build a better picture of how OHCA can be better managed and prevented.

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## Older People's Motivation to Use Falls Prevention Exergames

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This study investigated the factors that influenced the motivation of older people at risk of falls, to use falls prevention exergames to improve their physical function and reduce their fall risk. A mixed methods study was conducted in which 12 older people aged between 59 to 91 years participated. The results suggest that the older people are intrinsically and extrinsically motivated which indicates that exergames are a promising tool for fall prevention.

### Introduction

The proportion of older people is increasing worldwide.<sup>1,2</sup> In the UK, the proportion of older people is even higher compared to the average worldwide.<sup>3</sup> Older people are at increased risk of falls due to factors such as reduced physical strength, balance and the use of certain medications or large numbers of medications.<sup>4</sup> One in three people aged 65 years and older fall each year in the UK.<sup>3</sup> The consequences of a fall can vary; from a bruise or sprain to a traumatic brain injury or hip fracture. These consequences are related to decreased health and psychological well-being, and increased expenditure in the health care sector.<sup>5,6,7</sup> The consequences of a fall can also cause death, with approximately 3,653 older people dying due to a fall in the UK in 2013.<sup>3</sup> One of the best modifiable risk factors to reduce the fall risk among older people is physical exercise.<sup>8,9,10</sup>

To improve physical function and reduce fall risk, MIRA Rehab with the University of Manchester and users (older people and falls prevention therapists) has developed falls prevention exergames with and for older people. Exergames are videogames which combine gameplay with physical exercise. The exergames keep track of the client's performances e.g. speed, scores and number of games played.<sup>11</sup> The exercises in the exergames are based on the FaME and Otago exercise programs which are shown to reduce the risk of falling among older people.<sup>12,13,14</sup> To improve physical function and reduce the risk of falling, older people may be motivated to use the exergames for a longer period of

time. Nevertheless, it is unknown if and why older people are motivated to use falls prevention exergames. Therefore, the objective of this study is to investigate which factors influence the motivation of older people, who recover from a fall or who have a high risk of falling, to use falls prevention exergames to improve their physical function and reduce fall risk.

### Methods

Twelve older people, aged 59 to 91 years from two supportive housing facilities in North West of the UK, one physiotherapist and one warden (manager) participated in the study (see Table 1). The exergames were set up in a communal room in the two supportive housing facilities where the participants live. At one housing facility, the exergames were offered three times a week for 12 weeks and at the other housing facility, three times a week for six weeks. This is a mixed method study in which interviews, Technology Acceptance Model questionnaires and 81 hours of observation of the participants using the exergames were conducted. The interviews were transcribed and concurrently analysed using constant comparative analysis. After open coding, a coding framework was developed. The interviews were coded and analysed in Atlas.ti7 coding program. The questionnaires were analysed in Microsoft Excel 2010.

### Results

The findings of this study show that the participants are intrinsically and extrinsically motivated. They are intrinsically motivated because they enjoy playing the exergames and the use of the exergames appears to increase their physical, mental and social confidence. In addition, the social interaction which was provided in this study was an important extrinsic motivator which increased the intrinsic motivation to adhere to the falls prevention exergames. The participants are extrinsically motivated mainly because they have certain goals or outcomes which are important for them to reach: improving their physical function; improving their scores; and keeping their memory active. Also, it appears that the participants have a fear of ageing and the consequences of ageing. Fear is an intrinsic feeling caused by an extrinsic factor, which is ageing and the related consequences of ageing.

### Discussion

The use of mixed methods increases the validity of the findings.<sup>15</sup> The interviews, questionnaires and 81 hours of observations in general agree on the findings. Nevertheless, a limitation of this study is that not all



**Table 1.** Overview of participants' age, sex, impairments, marital status and number of weeks and exergame-sessions used.

Participant*	Age	Sex	Impairments	Marital status	#sessions/ weeks used
Ms Smith	67	Female	Depression with anxiety, Bipolar disorder	Engaged	15/6
Mr Darcy	89	Male		Single/never married	41/12
Ms Collins	66	Female	Depression**	Divorced	13/6
Mr Crawford	63	Male	Disability right hand	Single/never married	6/6
Ms Price	80	Female		Widowed	30/12
Mr Rushworth	66	Male		Single/never married	16/6
Ms Bertram	79	Female	Mild cognitive impairment	Widowed	13/9
Mr Wickham	60	Male	Depression with anxiety	Engaged	15/6
Mr Willoughby	76	Male		Single/never married	18/6
Ms Bennet	81	Female	Depression	Widowed	3/12
Ms Dashwood	91	Female		Widowed	24/12
Mr Ferrars	59	Male		Single/never married	2/6

\*The names of the participants are changed for anonymity

\*\* According to the DSM-IV criteria for depression and herself, this person suffers from a depression. However, this is not reported in her medical history.

19 older people who undertook the exergames program participated in this study. Seven older people decline to participate in this study because of reasons such as not feeling well enough for an interview, having appointments at hospital or being in hospital. This might indicate some selection bias in this study that might indicate overestimation of the motivation of older people towards exergames because most of the participants in this study adhered to the exergames for a longer period of time.

## Conclusion

Falls prevention exergames are a promising tool for fall prevention because the findings of this study show that older people can be intrinsically and extrinsically motivated to use the exergames for a longer period of time.

## Recommendations

The social setting appeared to be an important factor for the intrinsic motivation of enjoyment. Therefore it is recommended to incorporate social interaction with the exergames, for example during coffee breaks in a lounge of a supportive housing facility.

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**Ethical approval:** Approvals from both the University of Manchester and NHS Research Ethics Committees have been obtained before commencing participant recruitment. In addition, the study is conducted in full conformance with the principles of the Declaration of Helsinki, Good Clinical Practice and within the laws and regulations of the United Kingdom and the European Union.

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## Using Data from Low-cost, Off-the-shelf Devices to Monitor Exercise Adherence in Respiratory Patients, During Their Pulmonary Rehabilitation Programme

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Monitoring of physical activity can provide important data throughout pulmonary rehabilitation. This study aims to evaluate the feasibility of monitoring physical activity of respiratory patients through usage of low cost, off-the-shelf devices. This will include a wrist-worn pulse oximeter and a wrist-worn accelerometer, tested on both healthy subjects and patients performing a set of exercises from a pulmonary rehabilitation programme. The data coming out from this sensor integration are processed to extract useful information on movement intensity and quantity, to help improve quality of the rehabilitation programme.

## Introduction

A pulmonary rehabilitation programme consists of a set of physical exercises tailored for respiratory patients, with an aim to improve cardiovascular fitness over a period of several weeks. Currently, the evaluation of patients' progress is carried out only in a qualitative way, through supervision by physiotherapists and the use of questionnaires. A quantitative description of patients' physical activity, especially in a home environment, can guide physiotherapists and physicians through an improved provision of a rehabilitation programme. From literature, the possibility of quantifying physical activity can be achieved by usage of motion sensors, such as triaxial accelerometers<sup>1,2</sup> with intensity indexes (VMU, Vector Magnitude Units, which integrates the 3-axis accelerations in the way shown in *Methods* section).<sup>3,5</sup> Furthermore, these devices can be used for counting repetitions of several tasks.<sup>4</sup> Nevertheless, there is limited evidence regarding the use of combined pulse-oximetry and accelerometer data for monitoring physical activity,<sup>6</sup> particularly in

pulmonary rehabilitation programmes. The aim of this study was to investigate two low cost, off-the-shelf devices inclusive of a pulse-oximeter and an accelerometer to provide quantitative and multi-parametric assessment of patients' physical activity.

## Methods

This study evaluated motion during three commonly used pulmonary rehabilitation exercises, to address whether effort made by the end-user can be determined.

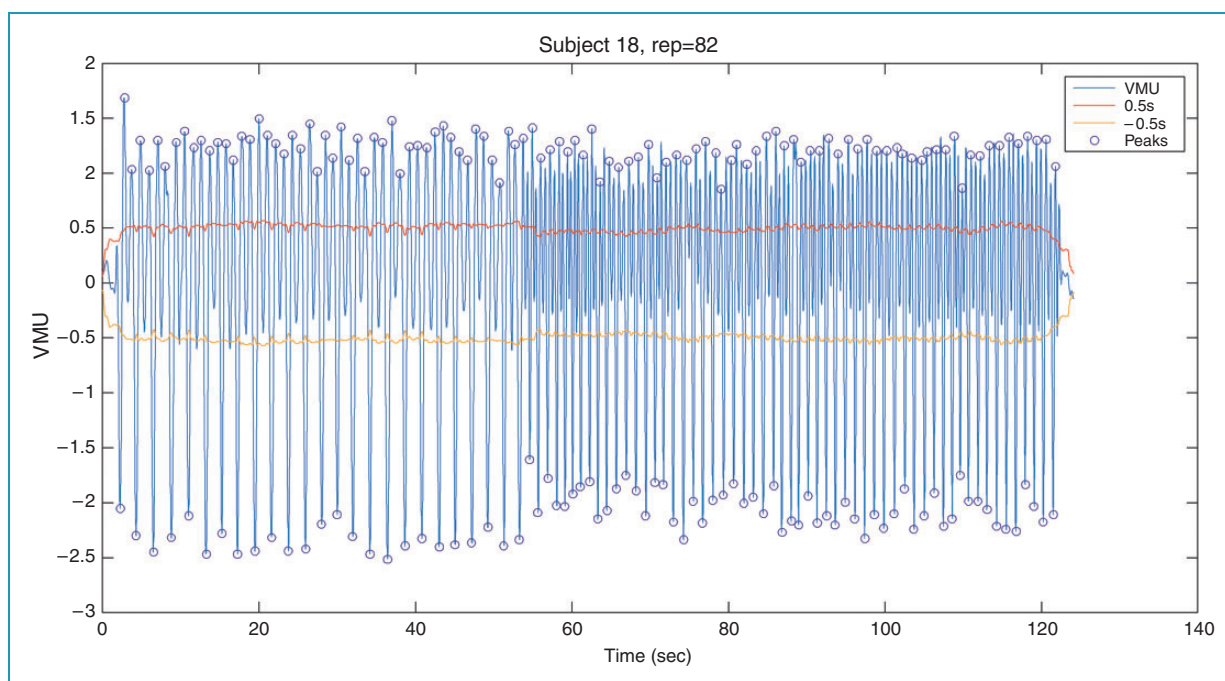
Three non-invasive wearable devices, were used to acquire the data: a wrist pulse oximeter (*Prince 110H/PC 68B*), a wrist accelerometer (*Texas Instruments ez430 Chronos*) and a waist worn inertial measurement unit (*BTS G-Walk*) used for comparison with the wrist accelerometer data. The accelerometer provided the acceleration amplitude of the arm in three dimensions, while the IMU (inertial measurement unit) supplied the angular rate and the acceleration amplitude of the waist in the three directions. Furthermore the pulse oximeter provides SpO2 (oxygen blood saturation) and heart rate signals. Healthy volunteers and respiratory patients in pulmonary rehabilitation classes were tested. The exercise protocol was designed in collaboration with a physician and physiotherapist. The acquisition protocol required 20 minutes for each session. At the beginning of each experiment, a balance sensor (i-Balance) was used to gather some physiological

data from the subject (weight, body fat, lean mass, muscle mass, bone mass, body water, body mass index (BMI), Daily Calorie Intake). Next, participants were asked to carry out three different physical exercises, in increasing intensity, with a resting period in between, as follows:

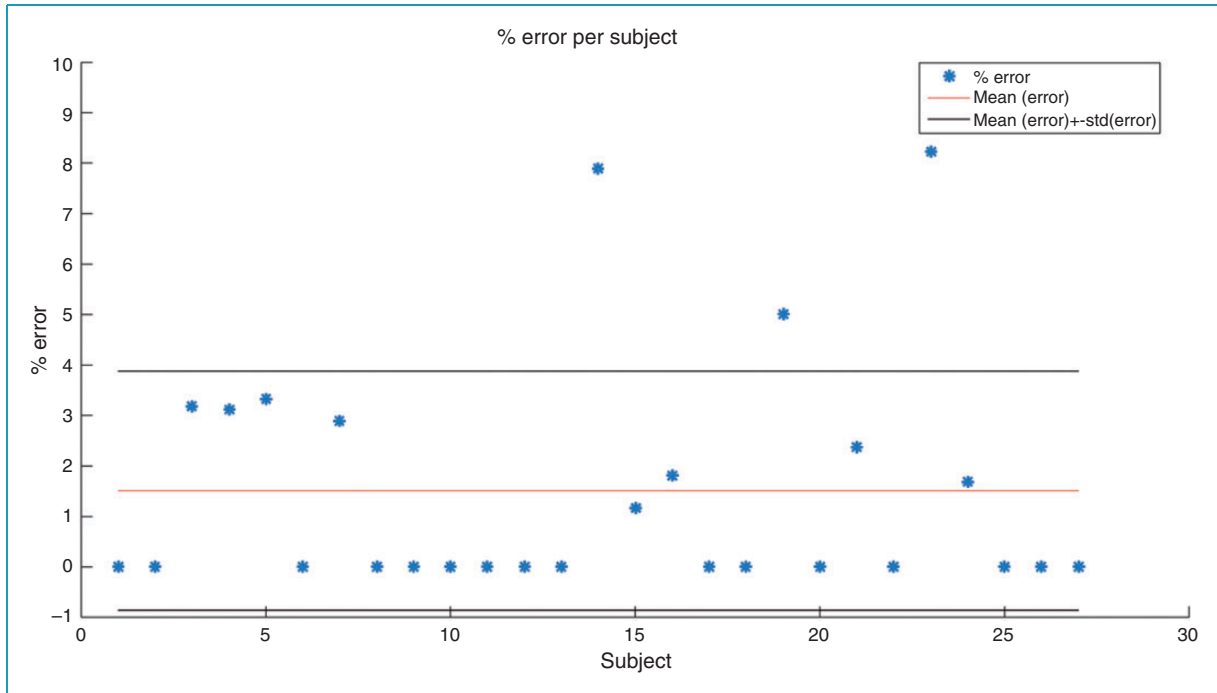
- 30 seconds of baseline reading: assessment of the baseline SpO2 (Oxygen Saturation) and Heart Rate
- 3 minutes of 'Ball Raise' exercise
- 3 minutes of Resting
- 5 minutes of 'Marching' exercise
- 3 minutes of Resting
- 2 minutes of 'Step Ups' exercise
- 5 minutes of resting

During the resting period, the perceived breathlessness of the patient was assessed using the Borg breathlessness scale. Movement signals from the accelerometers were filtered and aligned in Matlab in order to find reliable features and indexes for quantifying physical activity in terms of intensity and amount (also following the indication of the literature (e.g. exercise repetitions<sup>4</sup> and VMU<sup>1,2</sup>)). In particular, the calculus of the VMU consists of the square root of the sum of the squared filtered signals from each accelerometer axis (x, y, z):

$$VMU = \sqrt{acc_x^2 + acc_y^2 + acc_z^2}$$



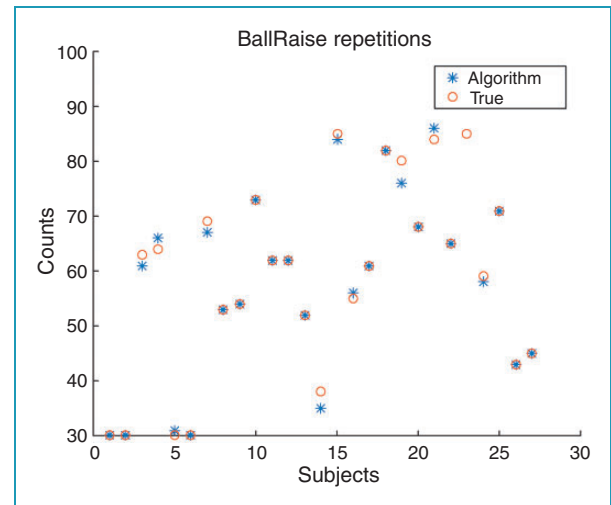
**Figure 1.** Transitions from a local minimum to a local maximum of the VMU signal, respectively beneath  $-0.5s$  ( $s$  = standard deviation) and above  $0.5s$ .



**Figure 2.** Relative % error per subject, average relative % error and its standard deviation.

In addition, signals from the wrist-oximeter, in combination with the accelerometers signals, were used to find, if existing, a model capable to explain the tasks performed by the participant in a multi-parametric way. Lastly, an explorative data analysis was conducted using the two samples, to understand if any clustering could be made; taking into account the physiological data collected from the i-Balance device.

At the moment, an algorithm for counting 'Ball Raise' exercise repetitions was developed, with a real-time perspective. In order to design, develop and test the algorithm, a set of 27 acceleration signals (VMUs), recorded by the wrist-mounted ez430 Chronos on 27 different subjects (15 women and 12 men), was considered. Firstly, in order to design a proper filter to apply to the VMU, a frequency domain analysis was conducted over the entire set, in order to define the range of frequencies related to the repetitive 'Ball Raise' exercise. For this purpose, each signal, after a resampling stage, from 30 to 60 Hz, was smoothed with a moving average filter of 15 samples. Successively, the frequency content of the resulting signal was computed and the overall frequencies range was found to reside between 0.3 Hz (slow repetitive movements) and 2 Hz (very rapid repetitive movements). Based on these findings, a 5<sup>th</sup> order Butterworth low pass filter was designed with a cutoff frequency of 2.5 Hz. Consequently, each VMU signal was filtered and the data set was split in a training set (15 VMU signals) and a test set (12 VMU signals). Then, to allow a real time counting,



**Figure 3.** Computed repetitions vs true repetitions.

the standard deviation of the moving window of 4 seconds (240 samples), centred on the  $i$ -th sample, has been computed. The algorithm counts a repetition whether a transition from a local  $i$ -th minimum, beneath the threshold of half of the negative  $i + 1$ -th standard deviation, to a local maximum, above the threshold of the half of the positive  $i + 1$ -th standard deviation, occurs (Figure 1). Decision rules, based on the intensity of the peak and the distance from the threshold, have been developed in order to discriminate true from false transitions.

Subject	True	Computed
1	30	30
2	30	30
3	63	61
4	64	66
5	30	31
6	30	30
7	69	67
8	53	53
9	54	54
10	73	73
11	62	62
12	62	62
13	52	52
14	38	35
15	85	84
16	55	56
17	61	61
18	82	82
19	80	76
20	68	68
21	84	86
22	65	65
23	85	92
24	59	58
25	71	71
26	43	43
27	45	45

**Figure 4.** Number of computed repetitions for each subject compared with the reference ones.

## Results

The study is currently underway. At the moment, results related to the ‘Ball Raise’ exercise show an overall good accuracy of the algorithm, previously described, for counting repetitions. As depicted in Figure 2, the relative error, defined as

$$\frac{|true\ repetitions - computed\ repetitions|}{true\ repetitions} \times 100$$

has been computed. An average relative error of 1.5% has been reached.

It is remarkable how 16 out of 27 countings perfectly match the true values, obtained by direct counting from two observers. Moreover, it is to underline how, over these 16 signals, various speeds are reached (Figure 3). Maximum relative errors (7.8% and 8.2%) have been reached for subject 14 and 23, with a mismatch of 3 and 7 repetitions respectively (Figure 4).

## Discussion

The explorative statistical analysis conducted on the integrated signals, from the accelerometer and the pulse-

oximeter, allow for comparison of oxygen saturation and movement intensity measurements during the execution of exercises. Once results are generated it will be possible to infer the effectiveness of these particular low cost devices to monitor physical activity in healthcare, particularly in a pulmonary rehabilitation programme. In addition, the findings could be further used to assess how such devices could be embedded in a single device and interfaced with a tablet application, designed for patient daily usage. This means that a way to provide simple and understandable information from the app should be investigated, in order to properly tailor a service to monitor the rehabilitation in a quantitative and multi-parametric way, and motivate the patient in carrying out as much physical activity as possible.

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## Facilitating Ecological Momentary Assessment through Visual Programming

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Ecological Momentary Assessment (EMA) methods capture patients' symptoms and feelings in real-time, in their everyday environments, allowing for regular contact and continuous monitoring between patient and clinician. Today, the proliferation of mobile technologies afford healthcare professionals opportunities to reach patients in varying contexts, but implementing such applications requires software developers, or expensive commercial tools. This presentation demonstrates our application to allow health professionals with no programming experience to develop their own EMA mobile apps.

### Introduction

Ecological Momentary Assessment (EMA) is a set of methods used by researchers and health professionals in the domains of psychology and medicine<sup>1</sup>. Via EMA, participants provide data 'in-situ', as they go about their everyday lives. This data could take the form of physical attributes and symptoms, or emotional attributes such as thoughts and feelings currently being experienced. It can be used both in research studies, and in real-world clinical settings for constant patient monitoring.

EMA minimises 'recall bias' where patients are otherwise required to recall their experiences at a previous time, which could be easily forgotten. Additionally, it allows for more frequent and long-term monitoring of patient attributes. In modern-day EMA studies, patients can provide information through their own mobile devices, possibly multiple times a day over a course of weeks or months<sup>2</sup>. This is a far more patient-centric approach to care, as long-term conditions can be more directly managed without requiring a patient to constantly return to a clinic, reducing the burden on both sides.

### Methods

Previously, the gold standard for obtaining 'in-the-moment' feedback was the use of pen-and-paper diaries. These are cumbersome and do not allow for continuous collaboration between patient and clinician. In order to make care more patient-centric, more direct communication is required, which we envision could be

achieved through the triggered delivery of surveys on a patient's mobile device. These would be completed on the device itself, and the results instantly available to a clinician for analysis. Real-time patient answers and compliance could be used to tailor an application to an individual's needs.

We have implemented 'Jeeves', a desktop environment that can be used to generate EMA study specifications by end-users with no prior programming experience. The specifications are converted to files that are interpreted by an Android smartphone app, through which surveys are directly delivered at appropriate moments. The primary requirement for *Jeeves* is that it should be usable by health professionals with minimal training and education.

We designed our environment's constructs and components by reviewing recent studies in the medical and psychology literature. By doing so, we were able to gain a stronger understanding of the requirements of such studies, so that *Jeeves* can be used to theoretically replicate many study specifications that were programmed from scratch or with an expensive commercial tool.

*Jeeves* is a *visual programming environment*, whereby EMA configurations are composed by dragging and dropping graphical "blocks". These connect like jigsaw puzzle pieces, where only correct pieces can fit together, eliminating syntactical errors associated with textual programming. Figure 1 demonstrates part of such a configuration. This particular configuration triggers when a patient receives an SMS. It will wait for 5 minutes, then send the user the "SMS Survey" to complete, along with an audible alarm. Until the user completes the survey, it will repeat this at 5-minute intervals. Triggers can be interval, signal or event-contingent<sup>1</sup> where events can be detected by Android smartphone sensors.

As these surveys are a key component of EMA, *Jeeves* includes a built-in survey editor. Through this, questions can be created of different types (including open-ended, multiple choice, and Likert scale options), also supporting conditional logic such that certain questions are only prompted by specific answers to previous questions. Figure 2 shows a screenshot of the creation of the 'SMS survey', where a multiple choice question is conditionally followed by a Likert scale question. It is also possible to store the answers to particular questions as 'variables', so that specifications can be tailored to an individual's responses.

### Results

To assess the usability of *Jeeves*, we took quantitative and qualitative measures from a user study with 20 student participants from our university. 11 had some programming experience, ranging from complete novice to expert, and 9 had none whatsoever.



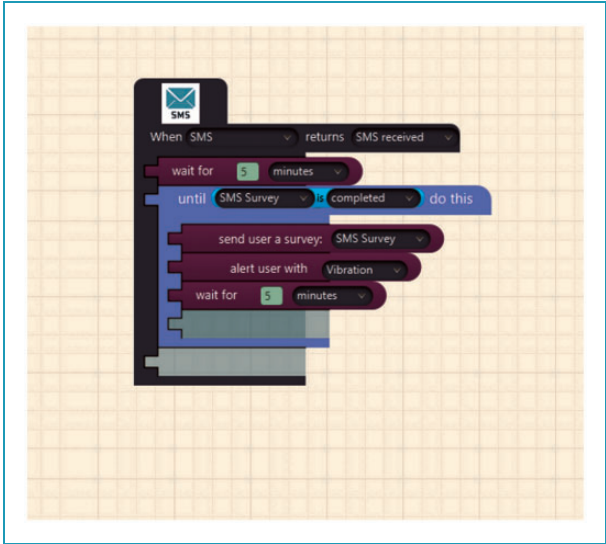


Figure 1. Example blocks in Jeeves for sending the ‘SMS survey’.

The study itself consisted of four tasks: 1. A step-by-step guide through the creation of a basic configuration; 2. Testing the readability and comprehensibility of a pre-built configuration; 3. Testing participants’ ability to modify this configuration with additional functionality; 4. Testing participants’ ability to build a configuration from the ground-up, based on an English-language specification.

Our quantitative results compared programmers and non-programmers on how usable they found the environment in completing the above tasks. We found no significant difference in usability scores from programmers and non-programmers, which were **71.8** (*SD* = 10.7) and **67.2** (*SD* = 13.9) respectively, as measured by the System Usability Scale<sup>3</sup>. Given that a score of 70 indicates a good standard of usability, this is a promising result. In our qualitative analysis, we coded end-of-study participant feedback into categories, and the frequency of positive/negative comments in each (see Figure 3 for results).

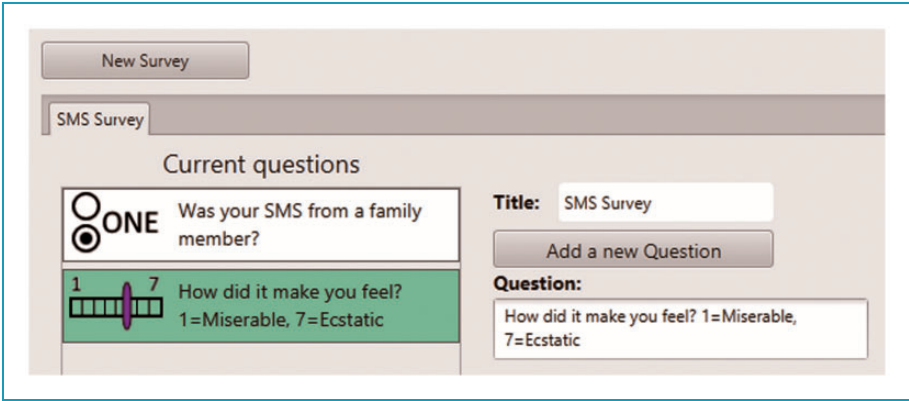


Figure 2. Segment of the survey creation form for editing the questions sent to patients.

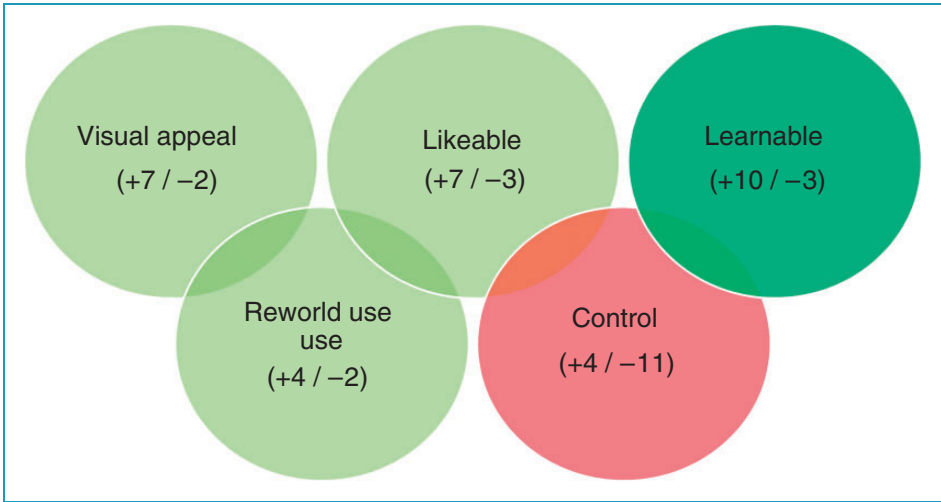


Figure 3. Positive/negative participant comments coded by category.

## Discussion

From the qualitative and quantitative results we obtained, it is clear that our application is usable by participants from a variety of study backgrounds and programming experiences. Categorisation of participant comments, particularly those by non-programmers, highlighted the learnability of the application – a promising result that provides us with confidence that *Jeeves* would lower the barriers to healthcare app development by non-programming clinicians, increasing the prevalence and associated benefits of such applications. Positive results for likeability and visual appeal also provide support for our block-based programming paradigm.

**Limitations** - We acknowledge that such results do not generalise to real-world use, where we would need to conduct such studies with clinicians who have a professional interest in using our environment. However, we treated this study as a feasibility analysis of *Jeeves* as a concept for use by programming novices. It was considered to be of primary importance to confirm that participants of varying programming experience could use *Jeeves* before testing with our target demographic, who are more difficult to recruit.

**Future work** - A future phase in our research, following a second iteration of the visual language's design cycle based on feedback, is to refine our Android application to allow robust EMA protocols to be run and tested in real-world situations. To ensure that our application is relevant, we are currently engaging with a number of healthcare professionals in order to elicit requirements that they may have for engaging with their patients through mobile devices. From an initial discussion with a local medical researcher, the issue of managing 'multimorbidity' has been brought to our attention. Challenges include the fragmentation of care knowledge across multiple doctors, as well as enabling patient-centric care where the burden of multiple different treatments is compounded by patient characteristics such as poor memory, lack of social support, or low motivation.<sup>4</sup>

We plan to study how *Jeeves* could be used as a means of cooperation between a patient and their various associated healthcare professionals, supporting the idea of "holistic" patient care<sup>5</sup>. The intuitiveness of the visual language means that it could be used by a clinician to visually describe and adjust a proposed protocol with their patient. By using *Jeeves* as a shared source of understanding, patients could take a more direct role in managing their own conditions through collaboration with their clinician.

## Conclusion

We have described *Jeeves*, a visual language and environment for the specification of Ecological Momentary

Assessment applications for Android smartphones. We have attempted to ensure its real-world applicability by recreating EMA study protocols from the literature, and conducted a usability study, in which we showed that the environment can be feasibly used by participants with no programming experience.

It is our belief that this technology will facilitate patient-centred care, through personalisation of configurations to an individual's needs, constant feedback and collaboration between patient and clinician, and the possibility of additional collaboration between multiple healthcare professionals to consider an individual patient's needs as a whole.

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**Ethical Approval:** The University of St Andrews Teaching and Research Ethics Committee (UTREC) approved this study (Reference number: CS11434). All participants gave written informed consent for inclusion in the study and publication of the results.

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## The Implementation of STarT BACK and an OA e-template: Utilising Existing GP Electronic Clinical Systems to Manage Patients with Low Back Pain or Osteoarthritis during a Routine Consultation

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The aim of these electronic template innovations is to remove barriers to implementation of clinical guidelines and assist clinicians in their consultations with patients with low back pain and or osteoarthritis. Utilising existing GP clinical systems it is possible to embed computerised templates, auto populated referral letters and embedded bespoke patient information to assist clinicians' management of these conditions and enhance, not hinder, the consultation process.

## Introduction

### STarT BACK Screening Tool

Patients with non-serious low back pain managed with a stratified care approach (screening tool plus matched treatments) have improved clinical outcome and is cost effective (Hill et al., 2011<sup>1</sup>). The STarT Back screening tool is a 9 item questionnaire that identifies patient's risk (low, medium or high) of developing persistent disabling back pain. Matched treatments are then provided according to need: GP advice, analgesia and supported self-management for low risk patients, traditional (manual) physiotherapy for medium risk patients and psychologically informed physiotherapy for high risk patients. However, this stratified approach is not being consistently embedded into practice.

### OA e-Template

Implementation of national (and international) guidance is often patchy with primary care management of osteoarthritis (OA) not being consistent with NICE guidance. The use of structured computerised forms

(templates) in consultation improves some aspects of clinical care including adherence to some processes of care GPs and practice nurses are used to such templates as part of their routine consultation recording (Edwards et al., 2014<sup>2</sup>)

For the two case examples above, we have designed, implemented and installed a new electronic template to guide and assist in the management of patients within primary care.

## Methods

### STarT BACK Screening Tool

In the initial phase, practices were identified by a local clinical Commissioning Group (CCG) as part of a West Midlands Academic Health Science Network (AHSN) funded innovation. A dedicated implementation team worked with GPs to design and test an IT solution which embedded the screening tool for stratified care into the GP electronic system. The CCG identified Quality Indicators that could monitor activity along the care pathway, and could sustain and promote professional and system level change. Use of the STarT Back tool, checking for red flags and appropriate referral on to physiotherapy will be measured. Small practice group meetings with GPs, practice nurses and practice managers were used to discuss the original evidence and to refine the screening tool into an IT based solution that could be easily incorporated into routine GP consultations. This solution has now been implemented and is live in 17 practices in the North Staffordshire and Stoke CCG's and we are working with North West Coast AHSN and CCG's in Birmingham Cross City, Hereford and South East Staffs and Seisdon and their associated Commissioning Support Units for Staffordshire and Lancashire and North of England to help implement the template.

### OA e-Template

The template is triggered by a wide range of OA and joint pain codes which were considered by a panel of 6 GPs to represent possible underlying OA. This template captures aspects of assessment and care not uniformly well-captured by the standard electronic record, including<sup>2</sup>:

- Pain and function assessments
- NICE guideline core interventions of information provision, exercise advice, and weight loss advice
- Physiotherapy use
- First-line analgesic use—paracetamol and topical non-steroidal anti-inflammatories (NSAIDs)

The implementation team are now working with Shropshire CCG to install and embed the template within GP practices in their area. In November 2015, the OA template was endorsed by NICE as part of a suite of tools to support the implementation of the OA NICE Guidance 2014.

## Results

Both of these clinical tools are currently available within one of the existing clinical systems in primary care (EMIS) in the first instance, with work on going to embed the STarT BACK tool within TPP SystemOne and INPS Vision systems.

### STarT BACK Screening Tool

A dedicated protocol and e-template has been co-created and embedded within EMIS to support GPs during consultations for low back pain. This includes an auto-calculated STarT Back score and a link to printable, bespoke patient information housed on patient.info. 'Pop up' advice for the GP is embedded dependent on the level of risk identified i.e. if low risk to be managed by GP, if medium risk refer to physiotherapy and if high risk refer onto physiotherapists with additional training. An electronic referral to physiotherapy services is automatically populated and generated if required, ensuring that evidence based pathways are readily accessible during the consultation.

The e-template was installed in 17 practices during the period January to November 2015.

During this period, January to November 2015:

- 866 patients consulted with back pain during this period and subsequently activated the e-template
- Of these patients, the tool was used on 190 patients (22%) with STarTBACK tool scores and/or risk factor recorded in the patient's medical record. Completion of this data was dependent on the version of the tool at the time, the latest version allowed both scores and risk factor to be recorded automatically.
- 97 patients were referred to physio as a result of the tools usage.
- 24 patients were provided with a copy of the STarTBACK specific patient information leaflet located on the Patient.info website.
- 17 patients were provided with a further information leaflet that provided website links to the Patient.info dedicated STarTBACK back pain pages and leaflet.

### OA e-Template

The original template was installed and used in 8 GP practices<sup>2</sup>. Evaluation of the template was positive. Approximately two-thirds of patients with OA or joint pain had at least one template entry completed. However, there was substantial variation between clinicians. A quarter completed at least one entry for 9 out of 10 patients but another quarter did not record any entry for more than half of their patients. Introduction of the template was associated with a significant increase in:

- Weight recording
- Prescription of NICE-approved first line analgesia e.g. topical NSAIDS<sup>2</sup>

Shropshire CCG have installed the OA e-template in their practices as part of a local enhanced service for OA, and their review of the orthopaedic pathway, which includes training of primary care practitioners in OA self-management strategies and high quality patient information (the OA Guidebook).

## Conclusion

Stratified care for back pain is clinically and cost effective. Embedding a template within GPs' existing clinical software ensures that research evidence can be implemented, and an easily accessible solution for a clinician to use the STarT Back tool in routine consultations.

Utilisation of a stratified approach helps to keep physiotherapy waiting lists low and embedding an auto-populated physiotherapy referral form within clinical systems makes it easier for GP's to follow evidence based care pathways in a busy clinical environment.

OA care has been highlighted as in need of improvement. Non-pharmacological interventions still need to be better-promoted. However, templates can assist with information capture (and audit) and processes of care and are a feasible method of integrating guidelines into routine working patterns. Better care for OA in general practice is achievable given appropriate multidisciplinary support. Non-pharmacological core treatments of education, exercise, and weight loss may require additional resources.

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**Ethical Approval:** No ethical approval was required at this stage as the tools form part of routine practice with any anonymised data audits being managed by the practice in accordance with normal IG arrangements.

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**Guarantor:** SW.

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## Stepping with a Virtual Partner: Exploring the Use of Virtual Reality Avatars for Gait Retraining

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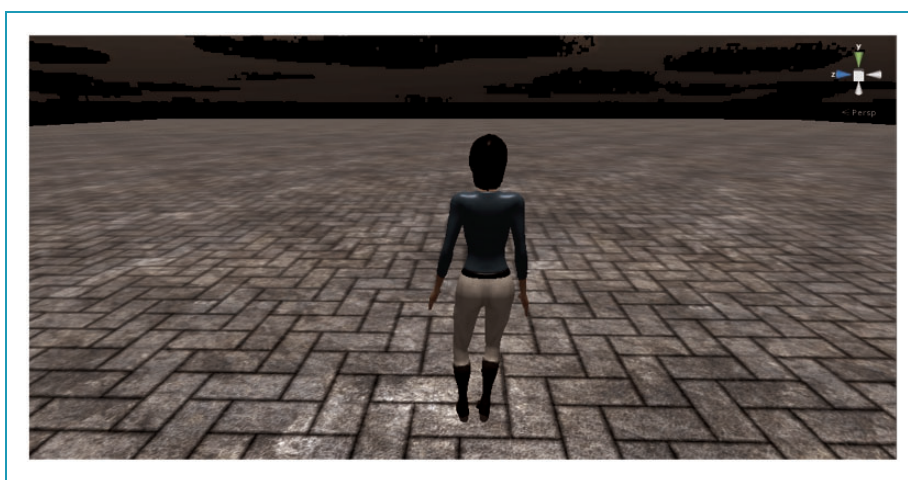
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This study investigates the use of avatars for retraining gait. Here, we completed a feasibility test by asking participants to step in time with the virtual partner viewed through a virtual reality headset. We observed that a perturbation (slowing down or speeding up one step cycle) applied to the avatar was reflected in participants' own step timing. Therefore, we suggest that virtual partners can potentially be used for gait retraining following neurological disease such as Stroke, or following major lower-limb surgery, such as hip and knee replacement.

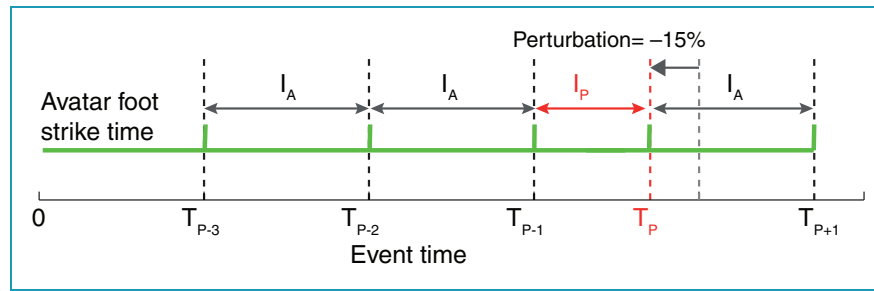
## Introduction

Stepping in time to rhythmic auditory cues can be effective for retraining gait following a stroke<sup>1</sup> or the onset of Parkinson's Disease<sup>2</sup>. Rhythmic visual cues can similarly influence coordination of movement, but are only effective when the cues have spatial as well as

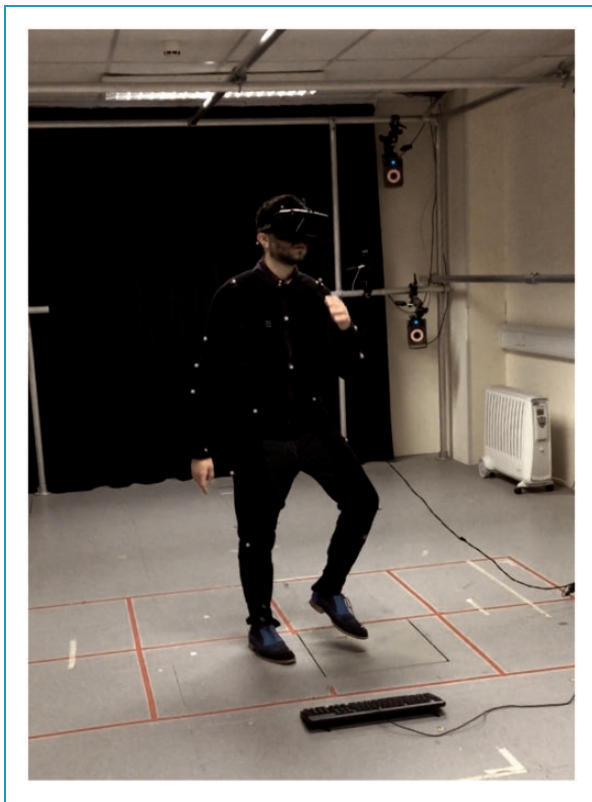


**Figure 1.** An example of the virtual environment and avatar presented to the participant during the trial.





**Figure 2.** Timing diagram illustrating a  $-15\%$  perturbation for the avatar during step P leading to a shortened inter-step interval of  $I_P$  and a heel strike time of  $T_P$ .



**Figure 3.** An image of one participant taking part in the trial wearing the Oculus Rift head mounted display and reflective Vicon markers for motion capture.

temporal dynamics<sup>3</sup> (e.g. a moving dot rather than a flashing dot).

A key goal of retraining gait is to improve adaptability so individuals can quickly correct movements in response to a sudden perturbation or obstacle<sup>4</sup>. Random phase perturbations can be inserted into otherwise regular auditory or visual rhythmic cues to force an adaptive response in the form of timing correction<sup>5</sup>. It is unknown whether complex visual cues such as an avatar can similarly influence step correction. However, imitation is an important human social characteristic<sup>6</sup> which

may influence an individual to accurately reflect their own movement coordination with that of an avatar.

Here we investigate if the corrective responses of healthy participants who are instructed to step in time with an avatar are influenced by perturbations to the avatar's gait. If participants are able to accurately follow the avatar's movements, then this could lead to more sensitive and targeted gait retraining methods.

## Methods

### Stimuli

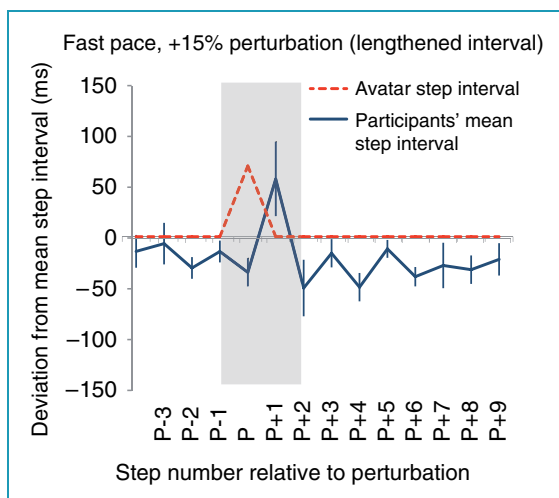
A single volunteer (Male, age 37 years, height 1.8 m) was recorded stepping on the spot using a 12-camera Vicon motion capture system. To set the tempo for each condition, the participant stepped in time with an auditory metronome with a beat interval of 450 ms (Fast) and 800 ms (Slow). Captured marker trajectories were mapped onto an avatar using Unity 3D software (see Figure 1). One of the avatar step cycles was accelerated or decelerated by 15% to create a perturbation (Figure 2).

### Experiment

Four participants completed the experiment; Participants wore an Oculus Rift virtual reality headset to view the avatar. They further wore reflective markers to capture their movements using a Vicon motion capture system. Participants were instructed to step on the spot in time with the avatar, unaware of the perturbation that took place on one of the step cycles (Figure 3). Participants completed 4 trials for each of the four conditions (Tempo [Slow, Fast] x Perturbation [+15%, -15%]).

### Analysis

Left and right heel step times were extracted from the movement trajectories. Inter-step intervals (ISI) were



**Figure 4.** Plot showing deviation from the mean inter-step interval across participants before and after the perturbation (step P) for the fast pace, lengthened interval trial. Participants significantly lengthened their step immediately following the avatar's perturbed step to regain synchrony.

then calculated as the time between heel onsets. A repeated measures ANOVA was used to statistically test for a change in participants' ISI following the perturbation.

## Results

Participants' mean step interval accurately matched the Avatar's very closely for both Fast and Slow conditions. Moreover, we observed a matching response in participants' step intervals to the perturbation step. Step intervals corresponding to one step after the perturbation were significantly shorter for the speeded perturbation ( $F_{1,2}=21.73$ ,  $p=.043$ ) and longer for the slowed perturbation ( $F_{1,3}=38.06$ ,  $p=.009$ ; Figure 4).

## Discussion

We have shown that an avatar's gait pattern in a virtual environment can be used to influence a person's own gait. In particular, when a perturbation is made to the avatar's step timing, the individual makes similar adjustments immediately after, when instructed to step in time with the avatar.

## Conclusion

This proof of concept study opens up the possibility of using virtual partners to retrain gait in individuals following neurological disease or musculoskeletal injury. Having a representative guide to the exercises is likely to improve adherence and subsequently reduce long term reliance on physiotherapy services.

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**Ethical Approval:** The ethics committee of BSREC approved this study (REC number: REGO-2015-1582). All participants gave written informed consent for inclusion in the study and publication of the results.

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